

Patent
Attorney Docket: LYNN/0144

IN THE CLAIMS:

Please amend the claims according to the following replacement claim set:

1. (currently amended): A method for selectively extracting one or more metal anion complexes from an aqueous solution, the method comprising:

contacting the aqueous solution with an organic solution including a diquatarnary amine, wherein the diquatarnary amine has two diquatarnary nitrogens spaced at a distance of less than about 10 Å, wherein the aqueous solution comprises anion complexes of one or more target metals and anion complexes of one or more other metals;

selectively binding the one or more target metal anion complexes to the diquatarnary amine; and then

separating the organic solution from the aqueous solution, wherein the diquatarnary amines having the selectively bound target metal anions complexes are concentrated in the organic solution.

2. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes comprise one or more platinum group metals.

3. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes are selected from anions of Pt, Pd, Rh, and combinations thereof.

4. (canceled):

5. (currently amended): The method of claim 4, wherein the ~~contaminant~~ other metals are selected from the group consisting of Pb, Al, Ba, Ce, Zr, Fe, Cu, Co, Ni, Mo, Sn, Sb, As, Bi, Zn, Na, K, Ca and combinations thereof.

Patent

Attorney Docket: LYNN/0144

6. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes comprise a metal selected from Ag, Au, Pd, Rh, Pt, Ru, Os, Ir, and combinations thereof.
7. (currently amended): The method of claim 1, wherein the distance between the two diquatarnary nitrogens is between about 5 Å less and 5 Å more than the size of the one or more target metal anion complex to be selectively extracted.
8. (currently amended): The method of claim 1, wherein the distance between the two diquatarnary nitrogens allows the formation of a complex between both diquatarnary nitrogens and the one or more target metal anion complex to be selectively extracted.
9. (original): The method of claim 1, wherein the aqueous solution is acidic.
10. (original): The method of claim 1, wherein the aqueous solution contains an acid selected from hydrochloric acid, sulfuric acid, nitric acid and combinations thereof.
11. (currently amended): The method of claim 9, wherein the diquatarnary amines are characterized in that the diquatarnary amines extract the one or more target metal anion complexes at all acid concentrations.
12. (original): The method of claim 1, wherein the aqueous solution is contacted with the organic solution for a time period of less than about 30 minutes.
13. (original): The method of claim 1, wherein the aqueous solution is contacted with the organic solution for a time period of less than about 20 minutes.
14. (original): The method of claim 1, wherein the aqueous solution is contacted with the organic solution for a time period of between about 5 minutes and about 20 minutes.

Patent
Attorney Docket: LYNN/0144

15. (original): The method of claim 1, wherein the concentration of the diquatarnary amines within the organic solution is between about 10% and saturation.
16. (original): The method of claim 1, wherein the concentration of the diquatarnary amines within the organic solution is between about 0.5 % and about 10%.
17. (currently amended): The method of claim 1, wherein the concentration of the diquatarnary amines within the organic solution ~~are~~ is between about 0.5 % and about 6 %.
18. (currently amended): The method of claim 1, wherein the concentration of the diquatarnary amines within the organic solution ~~are~~ is between about 1 % and about 5 %.
19. (original): The method of claim 1, wherein the organic solution has an organic solvent selected from chloroform, 1-octanol, methanol, and combinations thereof.
20. (original): The method of claim 1, wherein the organic solution has any of one or more water immiscible organic solvents in which the diquatarnary amines are soluble.
21. (original): The method of claim 1, wherein the diquatarnary amine is a diquatarnary ammonium halide that is essentially insoluble in water.
22. (original): The method of claim 1, wherein the two diquatarnary nitrogens are separated by an alkyl chain.
23. (original): The method of claim 22, wherein the alkyl chain is saturated.
24. (original): The method of claim 22, wherein the alkyl chain is unsaturated.

Patent
Attorney Docket: LYNN/0144

25. (original): The method of claim 22, wherein the alkyl chain is straight.
26. (original): The method of claim 22, wherein the alkyl chain is branched.
27. (original): The method of claim 1, wherein the two diquatarnary nitrogens are linked in a heterocyclic ring structure.
28. (original): The method of claim 27, wherein the ring structure is saturated.
29. (original): The method of claim 27, wherein the ring structure is unsaturated.
30. (original): The method of claim 27, wherein the ring structure is straight.
31. (original): The method of claim 27, wherein the ring structure is branched.
32. (original): The method of claim 21, wherein the diquatarnary ammonium halide comprises a halogen selected from iodine and chlorine.
33. (original): The method of claim 21, wherein the diquatarnary ammonium halide comprises a halogen selected from bromine and fluorine.
34. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes comprises a metal selected from Pd, Pt, Rh and combinations thereof, and wherein the two diquatarnary nitrogens are separated by an alkyl chain having 2 to 8 carbon atoms.

Patent

Attorney Docket: LYNN/0144

35. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes comprises a metal selected from Pd, Pt, Rh and combinations thereof, and wherein the two diquatarnary nitrogens are separated by an alkyl chain having 2 to 6 carbon atoms.

36. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes comprises a metal selected from Pd, Pt, Rh and combinations thereof, and wherein the two diquatarnary nitrogens are separated by an alkyl chain having 2 to 3 carbon atoms.

37. (currently amended): The method of claim 3421, wherein the diquatarnary ammonium halide is a chloride.

38. (currently amended): The method of claim 3421, wherein the diquatarnary ammonium halide is an iodide.

39. (currently amended): The method of claim 1, wherein the one or more target metal anion complexes comprises a metal selected from Pd, Pt, Rh and combinations thereof, and wherein the two diquatarnary nitrogens are part of a heterocyclic ring structure having 2 to 8 carbon atoms.

40. (original): The method of claim 39, wherein the diquatarnary ammonium halide is selected from a chloride, an iodide, and combinations thereof.

Patent
Attorney Docket: LYNN/0144

41. (currently amended): A method for recovering Pd and Pt metals from a spent catalyst comprising:

dissolving the Pd and Pt ~~metals~~ into an acidic solution to form Pd and Pt~~metal~~ anion complexes;

contacting the acidic solution with an iodide;

separating the iodide from the acidic solution, wherein the Pd anion complexes ~~is~~are bound to the iodide;

contacting the acidic solution with an organic solution including a diquaternary amine, wherein the distance between two diquaternary nitrogens is less than about 10 Å;

selectively binding the Pt anion complex to the diquaternary amine; and

separating the organic solution from the aqueous solution, wherein the diquaternary amines having the bound Pt anion complex are concentrated in the organic solution.

42. (original): The method of claim 41, wherein the acidic solution contains acids selected from hydrochloric acid, sulfuric acid, nitric acid and combinations thereof.

43. (original): The method of claim 41, wherein the iodide is selected from potassium iodide, sodium iodide, magnesium iodide, calcium iodide and combinations thereof.

44. (original): The method of claim 41, wherein the iodide is an organic iodide.

45. (original): The method of claim 41, wherein the iodide is an inorganic iodide.

Patent

Attorney Docket: LYNN/0144

46. (currently amended): A method for recovering palladium from an aqueous solution, comprising:
contacting the aqueous solution with an iodide and an organic solvent, wherein the iodide is selected from potassium iodide, sodium iodide, magnesium iodide, calcium iodide and combinations thereof;

allowing the palladium to bind to the iodide; and then

separating the organic solution from the aqueous solution, wherein the iodide having the bound palladium ions are concentrated in the organic solution.

47. (currently amended): A method for selectively extracting one or more metal anion complexes from an aqueous solution, the method comprising:

contacting the aqueous solution with a diquatarnary amine, wherein the distance between two diquatarnary nitrogens is less than about 10 Å;

binding the one or more metal anion complex to the diquatarnary amine; and then

separating the diquatarnary amine from the aqueous solution, wherein the diquatarnary amine is bound to a solid surface of an inert substrate.

48. (currently amended): The method of claim 47, wherein the one or more metal anion complexes comprises one or more platinum group metals.

49. (currently amended): The method of claim 47, wherein the diquatarnary ~~amines are~~ amine is bound to a solid surface by means selected from adsorption and chemical bonding.

50. (original): The method of claim 47, wherein the inert substrate is a polymer.

Patent
Attorney Docket: LYNN/0144

51. (currently amended): A method for recovering valuable metals comprising:

a. dissolving the metals into an aqueous acidic solution to form anions of the metals, wherein the metals comprise Pd, a second valuable metal, and a third valuable metal;

b. contacting the acidic solution with an iodide;

c. separating the iodide from the acidic solution, wherein the anions of Pd are bound to the iodide;

d. contacting the acidic solution with a first organic solution including a first diquatarnary amine, wherein the distance between two diquatarnary nitrogens in the first diquatarnary amine is less than about 10 Å and wherein the first diquatarnary amine is a selective extractant for the anions of the second valuable metal;

e. selectively binding the second valuable metal anions to the first diquatarnary amine; and then

f. separating the organic solution from the aqueous acidic solution, wherein the first diquatarnary amine has the selectively bound second valuable metal anions concentrated in the organic solution.

g. repeating ~~steps d~~ through f, using a second diquatarnary amine to selectively extract ~~a~~ the anions of the third valuable metal.

52. (new): The method of claim 51, wherein the iodide is selected from potassium iodide, sodium iodide, magnesium iodide, calcium iodide and combinations thereof.

53. (new): The method of claim 51, wherein the iodide is an organic iodide.

54. (new): The method of claim 51, wherein the iodide is an inorganic iodide.

55. (new): The method of claim 27, wherein the heterocyclic ring structure is a cyclic piperazine derivative.

Patent
Attorney Docket: LYNN/0144

56. (new): The method of claim 1, wherein the diquatarnary amine has an alkyl group having at least 10 carbon atoms.

57. (new): The method of claim 1, wherein the diquatarnary amine has at least one side chain having more than 12 carbon atoms.

58. (new): The method of claim 1, wherein the diquatarnary amine has at least one side chain having less than 7 carbon atoms.

59. (new): The method of claim 1, wherein the one or more metal anion complexes comprise one or more precious metals.

60. (new): The method of claim 1, wherein the diquatarnary amine is prepared by the reaction between a tertiary diamine and alkyl halide.

61. (new): The method of claim 1, wherein the diquatarnary amine is prepared from a diamine selected from tetramethylethylenediamine, tetramethylbutanediamine, tetramethyl propanediamine, tetramethyl hexanediamine and dimethylpiperazine.

62. (new): The method of claim 1, wherein the diquatarnary amine is bis-octadecyl, methyl piperazine ammonium chloride.

63. (new): The method of claim 1, wherein the diquatarnary amine is bis-decyl, methyl-piperazine ammonium chloride.

64. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, octadecyl ethylene diammonium chloride.

Patent

Attorney Docket: LYNN/0144

65. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, decyl ethylene diammonium chloride.
66. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, octadecyl propyl diammonium chloride.
67. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, decyl propyl diammonium chloride.
68. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, octadecyl butyl diammonium chloride.
69. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, decyl butyl diammonium chloride.
70. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, octadecyl hexyl diammonium chloride.
71. (new): The method of claim 1, wherein the diquatarnary amine is dimethyl, decyl hexyl diammonium chloride.
72. (new): The method of claim 1, wherein the diquatarnary amine is bis-hydroxyethyl, octadecyl piperazine ammonium chloride.
73. (new): The method of claim 1, wherein the diquatarnary amine is diethyl, octadecyl propyl diammonium chloride.

Patent

Attorney Docket: LYNN/0144

74. (new): The method of claim 1, wherein the diquatarnary amine is bis-hydroxyethyl, eicosyl piperazine ammonium bromide.

75. (new): The method of claim 1, wherein the diquatarnary amine is diethyl, eicosyl propyl diammonium bromide.

76. (new): The method of claim 1, wherein the diquatarnary amine is bis-hydroxyethyl, docosyl piperazine ammonium bromide.

77. (new): The method of claim 1, wherein the diquatarnary amine is diethyl, docosyl piperazine diammonium bromide.

78. (new): The method of claim 2, wherein the diquatarnary amine is bis-octadecyl, methyl piperazine ammonium chloride.

79. (new): The method of claim 2, wherein the diquatarnary amine is bis-decyl, methyl-piperazine ammonium chloride.

80. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, octadecyl ethylene diammonium chloride.

81. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, decyl ethylene diammonium chloride.

82. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, octadecyl propyl diammonium chloride.

Patent
Attorney Docket: LYNN/0144

83. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, decyl propyl diammonium chloride.

84. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, octadecyl butyl diammonium chloride.

85. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, decyl butyl diammonium chloride.

86. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, octadecyl hexyl diammonium chloride.

87. (new): The method of claim 2, wherein the diquatarnary amine is dimethyl, decyl hexyl diammonium chloride.

88. (new): The method of claim 2, wherein the diquatarnary amine is bis-hydroxyethyl, octadecyl piperazine ammonium chloride.

89. (new): The method of claim 2, wherein the diquatarnary amine is diethyl, octadecyl propyl diammonium chloride.

90. (new): The method of claim 2, wherein the diquatarnary amine is bis-hydroxyethyl, eicosyl piperazine ammonium bromide.

91. (new): The method of claim 2, wherein the diquatarnary amine is diethyl, eicosyl propyl diammonium bromide.

Patent

Attorney Docket: LYNN/0144

92. (new): The method of claim 2, wherein the diquatarnary amine is bis-hydroxyethyl, docosyl piperazine ammonium bromide.

93. (new): The method of claim 2, wherein the diquatarnary amine is diethyl, docosyl piperazine diammonium bromide.

94. (new): The method of claim 6, wherein the diquatarnary amine is selected from bis-octadecyl methyl piperazine ammonium chloride, bis-decyl methyl-piperazine ammonium chloride, dimethyl octadecyl ethylene diammonium chloride, dimethyl decyl ethylene diammonium chloride, dimethyl octadecyl propyl diammonium chloride, dimethyl decyl propyl diammonium chloride, dimethyl octadecyl butyl diammonium chloride, dimethyl decyl butyl diammonium chloride, dimethyl octadecyl hexyl diammonium chloride, dimethyl decyl hexyl diammonium chloride, bis-hydroxyethyl octadecyl piperazine ammonium chloride, diethyl octadecyl propyl diammonium chloride, bis-hydroxyethyl eicosyl piperazine ammonium bromide, diethyl eicosyl propyl diammonium bromide, bis-hydroxyethyl docosyl piperazine ammonium bromide, and diethyl docosyl piperazine diammonium bromide.

95. (new): The method of claim 41, wherein the diquatarnary amine is selected from bis-octadecyl methyl piperazine ammonium chloride, bis-decyl methyl-piperazine ammonium chloride, dimethyl octadecyl ethylene diammonium chloride, dimethyl decyl ethylene diammonium chloride, dimethyl octadecyl propyl diammonium chloride, dimethyl decyl propyl diammonium chloride, dimethyl octadecyl butyl diammonium chloride, dimethyl decyl butyl diammonium chloride, dimethyl octadecyl hexyl diammonium chloride, dimethyl decyl hexyl diammonium chloride, bis-hydroxyethyl octadecyl piperazine ammonium chloride, diethyl octadecyl propyl diammonium chloride, bis-hydroxyethyl eicosyl piperazine ammonium bromide, diethyl eicosyl propyl diammonium bromide, bis-hydroxyethyl docosyl piperazine ammonium bromide, and diethyl docosyl piperazine diammonium bromide.

Patent
Attorney Docket: LYNN/0144

96. (new): The method of claim 47, wherein the diquatary amine is selected from bis-octadecyl methyl piperazine ammonium chloride, bis-decyl methyl-piperazine ammonium chloride, dimethyl octadecyl ethylene diammonium chloride, dimethyl decyl ethylene diammonium chloride, dimethyl octadecyl propyl diammonium chloride, dimethyl decyl propyl diammonium chloride, dimethyl octadecyl butyl diammonium chloride, dimethyl decyl butyl diammonium chloride, dimethyl octadecyl hexyl diammonium chloride, dimethyl decyl hexyl diammonium chloride, bis-hydroxyethyl octadecyl piperazine ammonium chloride, diethyl octadecyl propyl diammonium chloride, bis-hydroxyethyl eicosyl piperazine ammonium bromide, diethyl eicosyl propyl diammonium bromide, bis-hydroxyethyl docosyl piperazine ammonium bromide, and diethyl docosyl piperazine diammonium bromide.

97. (new): The method of claim 48, wherein the diquatary amine is selected from bis-octadecyl methyl piperazine ammonium chloride, bis-decyl methyl-piperazine ammonium chloride, dimethyl octadecyl ethylene diammonium chloride, dimethyl decyl ethylene diammonium chloride, dimethyl octadecyl propyl diammonium chloride, dimethyl decyl propyl diammonium chloride, dimethyl octadecyl butyl diammonium chloride, dimethyl decyl butyl diammonium chloride, dimethyl octadecyl hexyl diammonium chloride, dimethyl decyl hexyl diammonium chloride, bis-hydroxyethyl octadecyl piperazine ammonium chloride, diethyl octadecyl propyl diammonium chloride, bis-hydroxyethyl eicosyl piperazine ammonium bromide, diethyl eicosyl propyl diammonium bromide, bis-hydroxyethyl docosyl piperazine ammonium bromide, and diethyl docosyl piperazine diammonium bromide.

Patent

Attorney Docket: LYNN/0144

98. (new): The method of claim 51, wherein the first and second diquatery amine are independently selected from bis-octadecyl methyl piperazine ammonium chloride, bis-decyl methyl-piperazine ammonium chloride, dimethyl octadecyl ethylene diammonium chloride, dimethyl decyl ethylene diammonium chloride, dimethyl octadecyl propyl diammonium chloride, dimethyl decyl propyl diammonium chloride, dimethyl octadecyl butyl diammonium chloride, dimethyl decyl butyl diammonium chloride, dimethyl octadecyl hexyl diammonium chloride, dimethyl decyl hexyl diammonium chloride, bis-hydroxyethyl octadecyl piperazine ammonium chloride, diethyl octadecyl propyl diammonium chloride, bis-hydroxyethyl eicosyl piperazine ammonium bromide, diethyl eicosyl propyl diammonium bromide, bis-hydroxyethyl docosyl piperazine ammonium bromide, and diethyl docosyl piperazine diammonium bromide.